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THESIS

Materials Handling with Applications to a Foundry

by

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CONTENTS

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LIST OF EXHIBITS IN APPENDIX

INTRODUCTION

In the past twenty-five or thirty years great advances have been made in modern industry. We have seen the growth of the mass production industries as the result of improved processes and techniques. The emphasis has been placed on more goods at cheaper cost. Great advances have been made in all fields but one seems to have been less developed and that is the part of materials handling in modern industry. With the advent of mass production the problem of handling the increased quantities has magnified many times.

Today the need for reductions in production costs has increased and the one field where large savings can be made is in materials handling. The problem varies in importance depending upon the situation, but on an average the cost of handling materials constitutes about 22% of the total cost of manufacturing. (1) Approximately one fifth of the price we pay for many articles is the result of materials handling costs.

In this paper an attempt will be made to show how to cope with the handling problems. The problems, it is realized, differ in almost every situation so this paper is written in the hope that a system may be described which will be an aid in solving any handling problem.

The paper advocates the knowledge of several principles of materials handling which, though seemingly general in nature, can be effective in finding a solution to a handling problem. These principles

1. Alford, L. P., and Bangs, J. R., Production Handbook, Ronald Press, New York, 1944. Page 936.

of good handling are applicable to any handling situation.

Along with the principles, the types of equipment available are also given. The combination of the principles with the types of equipment available give the means to correctly solving a handling problem.

The paper will also take an actual case and show how these principles are used in actual practice.

CHAPTER 1

MODERN MATERIALS HANDLING

The scope of materials handling is so large that it is difficult to find any one definition that covers the subject completely. One of the best definitions is found in the "Cost and Production Handbook", Section 17.

> Handling materials is picking up and putting down, translation in a horizontal or vertical plane, or combination thereof, by any means whatsoever, of all materials of nature, gaseous, liquid or solid in their raw, semi-finished or completely converted condition. (1)

On reading this definition one gets the idea that materials handling concerns itself with the movements of any material, anywhere and by any means. Technically speaking this may be true, but in general usage the term materials handling is more restricted. One probably wonders where the line is drawn between materials handling and transportation such as railroads and trucks. They may wonder if there is any difference. Though technically speaking these means do come under the heading of materials handling, there seems to be some distinction as is best shown by the following:

> All materials handling is transportation and all transportation is materials handling. In industry, however, there is a distinction between the two terms.
>
> As we usually understand it, materials handling relates to the movements of materials within the plant or warehouse and at loading stations, etc. On the other hand, transportation applies to movements by railroad, truck or ship. (2)

1. Alford, L. P. (Ed.), Cost and Production Handbook, New York, Ronald Press Co., 1934. Sec. 17, Pp. 851.

2. Migula, G. V., "Materials Handling Principles", Mechanical Handling, Vol. 33, Sept., 1946.

The combination of these two definitions seems to cover the scope of materials handling as it applies today to modern industry, but it must not be forgotten that handling problems are just as big a factor with railroads, trucking companies, and shipping lines as they are in warehouses, stores, mines, factories, power plants and construction companies.

Within industry the problem of handling materials may be divided into three main divisions. These being:

1. Unloadingraw materials and parts, from rail, truck or ship and storing them.
2. Movements of the material in the manufacturing or converting process.
3. Packaging and loading the finished product for shipment.

These three functions have to be performed in any processing industry, and can, with modification be applied to any business. In a department store, for example, number one would be unloading the merchandise and placing it in storage; number two, moving it to the display counters, and number three, wrapping the purchases up and either giving them to the buyer to take out or delivering.

Though the problems may vary in each case, there should be one thought paramount upon the mind of anyone attacking a handling problem. That aim should be to do away with movement altogether. Or stated in a different way, "Economy in moving materials is secured by not handling". (1)

1. Alford, L. P. (Ed.), Cost and Production Handbook, New York, Ronald Press Co., 1934, Sec. 17, Pp. 852.

It must be remembered that handling is not a productive function. It is an aid to production, true, yet in reality it is an unnecessary function. It may be considered as a necessary evil. The ideal situation for any processing plant would be that where there is no handling. The materials would go from one machine to the next without any handling, yet, this is seldom if ever the case. Material handling problems may be considered as the result of some person's inability to solve a layout or arrangement problem.

In general, we can say that one of the aims of any manufacturing plant, warehouse or power plant is to perform its function more economically. Competition usually compels one to do this. Today the industries of the United States are confronted with the problem of combating an inflationary spiral by producing more goods. Costs should be kept down. Materials handling, though not the only solution to the problem, can help greatly.

The advantages of efficient materials handling are many. First, and of primary interest, is that it can cut costs. Whenever handling devices have been installed it has been found that the cost rate per hour for the new equipment is only a fraction of the hourly wage for labor, yet the total work performed is many times more. (1) That is, one handling device may be able to replace many men performing manual labor and thus show greatly reduced costs. It surplants not only those men directly engaged in handling but often times skilled workmen who have to leave their machines to go for materials or spend a great percentage of

1. Mallick, R. W., "Facing the Problem of Materials Handling", Mechanical Handling, Vol. 34, June, 1947.

their time picking up and putting down the pieces they work on. It was found in a recent survey of twenty-one Westinghouse plants that the materials were actually worked on only a small percentage of the time, (40%) and the rest of the time they were being handled and often times by skilled men. (1) Ideally a skilled machinist, molder or workman should tend his machine or do nothing but mold all day as the case may be. Efficient handling should enable one to attain this situation.

There is still another way in which costs are cut and that is, that working capital is not tied up as long. The ideal situation for a manufacturing plant would be, that, in which the materials in process are cut down to a minimum. That is, every machine and man is supplied amply but there are no storage pools or excess amounts of materials in process. By cutting down the amount of material in process, we cut down the amount we have to tie up in working capital for any length of time. It must be remembered that cutting down material in process to a minimum introduces the possibility and danger of shutdowns for lack of material. For this reason, some extra material should be supplied and a more primitive means of handling, such as hand movement, ready in case of breakdowns.

Good materials handling also helps to utilize every square foot of factory space most effectively. It does away with storage pools giving more space for productive machines. It helps to cut down overhead by utilizing floor space for productive work and thus cuts operating expenses. Efficient handling also enables one to more effectively utilize

1. Mallick, R. W., "Facing the Problem of Materials Handling", Mechanical Handling, Vol. 34, June, 1947.

square footage of floor space by enabling one to stack skids and pallets higher than could be effectively done by hand labor.

Production capacity is also increased with good handling. There is a faster flow through the plant. The machines are always loaded and there are no delays or shutdowns. Floor spaces otherwise used for storage or not even used can be utilized for productive means, thus increasing production.

There is also a smoother flow of production with good handling. This cuts out delays and increases efficiency. With a handling system installed, production becomes more routine which makes it easier to train employees and also enables responsibility for jobs to be placed easier and more definitely. This helps to facilitate management and administration of the plant.

With a smooth flow of production, it is also easier to schedule orders more definitely and give reasonable and reliable estimates on when orders are to be ready. Though there are other advantages to good materials handling, these seem to be the most prominent and by far the most important. In summary, we can say good handling offers:[1]

1. Increased output.
2. Lower cost of production.
3. A smoother flow of production.
4. Reduced materials in process and thus reduced tie-up of working capital.
5. Speedier and more accurate delivery dates.
6. Aids management and adminstration.

1. Koshkin, S. J., Modern Materials Handling, New York, John Wiley and Sons, Inc., 1932, Page 2.

It must be remembered that these results are obtainable with good handling installations and not with haphazard selection of equipment to fill some need.

There are various opinions as to how big the problem of handling is in modern industry. Some people estimate that the cost of handling is 90% of the total manufacturing cost and others vary this figure downward as low as 10%. Of course, some processes require more handling than others which might be one of the reasons for the variations, but there is still a more basic reason. That is that manufacturers have never bothered to separate handling costs from other factory costs. They are usually hidden away in overhead or operating costs.

At a recent Materials Handling Convention in Cleveland, C. M. White, President of Republic Steel Corporation, put it this way:

> We forget that much of our total manufacturing procedure is based on materials handling. Each progressive step from machine to machine or from department to department involves a problem of handling materials. But we do not pay any freight bills for this interior handling, so too often we have no idea of what it costs. It remains a hidden charge against total manufacturing costs about which we have little information. (1)

Some manufacturers have started to separate handling costs from total manufacturing cost. This practice should continue since handling is such a large factor in industry, and by having cost records for handling expenditures, a real means of comparing the efficiency of different handling systems and devices may be obtained.

The importance of materials handling is being realized more every day. One author on the subject says that the cost of production

1. Modern Materials Handling, Materials Handling Laboratories, Boston, Mass., March 1947. Page 24.

is almost directly proportional to the cost of handling materials. It is not a small proportion either and is a problem not only to be considered by lesser executives of industry but top management as well. Progress is being made in the field of materials handling. The best way to do it is by research and the exchange of knowledge. That is what is now being done more than ever. The International Harvester Corporation has started a materials handling research laboratory with large testing space. It is going into the problems of selection, maintenance, costs and new applications. Projects like this are needed if there is to be any real advancement in the field. A materials handling association is also forming in the larger cities throughout the country for the exchange of information.

Their objectives are better handling at lower cost. One of the most important factors these organizations are considering is the idea of standardizing materials handling equipment, for by standardization more economies of production of the actual handling equipment may be obtained. Economies which can eventually be made available to the ultimate purchaser. As it is today, there are various models of each different type of handling equipment and some of the variations are so slight that the increased cost to produce them does not warrant the variation.

There are no set formulas for the solution to handling problems and the type of equipment to use in various cases. The best way seems to be to know the types of handling equipment available and the general principles or rules of handling that one should keep in mind whenever attacking a handling problem. The combination of these two factors should give an effective solution to any handling problem. For this reason, the

next chapter is devoted to the types of equipment available and the following one to the principles or rules of handling.

CHAPTER 2

MATERIALS HANDLING EQUIPMENT

A concise and thorough definition of materials handling equipment is contained in the Production Handbook, Page 935. It states:

> Handling equipment refers to all mechanisms used in materials handling, together with auxiliary devices that may be required to make complete operating units. (1)

If we refer back to the definition of materials handling in the previous chapter, we can see that the equipment can "pick up, put down, transport horizontally or vertically or any combination thereof". This gives an idea of the wide variety of functions that the various equipment is called upon to perform.

In keeping with the idea of the function performed, some authors have grouped handling equipment according to function. That is, they are either lifting devices, lowering devices, or transporting devices. This is not the only means of classification as it can be classified according to type, such as trucks, cranes or conveyors. The Production Handbook specifies three other means of classifying equipment along with the two already mentioned. The remaining three are:

1. According to the nature of the material handled which would be bulk handling equipment, package handling equipment, ...
2. According to the industry served such as construction, mining, ...

1. Alford, L. P. and Bangs, J. R. (Ed.), Production Handbook, Ronald Press, New York, 1944. Pp. 935.

3. According to relative mobility such as limited area service, fixed path, ...

There are advantages to the different ways of classifying the equipment. If the plant is laid out and the places from and to which the material are known, then by reference to the layout one can see if the material is lifted, lowered, transported or a combination of these. Reference to the classification according to movement will give a quick picture of what is available to do the job. Usually there is some piece of equipment in every group that will be able to take care of the material. Classification according to the nature of the materials handled is useful if one attacks the problem from the viewpoint of the characteristics of the materials to be handled. The material to be handled is a big factor in the selection of the equipment.

For all practicable purposes, classification according to the nature of the service performed seems to be best. There are devices on the market that perform a definite function, such as lifting, and enough variations of these to adapt them to most any kind of material. Thus, if we make a list according to function and supplement it by showing its principle applications, we have a list showing both the nature of the service and what materials can be economically handled by the means. The Production Handbook has done just this. The list is very complete and will be reproduced here. (1)

1. Ibid, Page 8, Pages 944-945

1. Lifting and Lowering Devices (vertical motion)

a. Block and tackle ....Local hoisting
b. Winches
   Hand ....Cargo handling
   Power..Cargo handling
c. Hoists (fixed)
   Chain.................................... Local service in
   Air......................................foundries, machine and
   Electric.................................woodworking shops, etc.
d. Skip hoists..............................Coal and ash handling
e. Hoisting engines.........................Construction service
f. Elevators
   Hand.....................................Multistory manufacturing
   Belted...................................plants, serving charging
   Hydraulic................................platforms in foundries,
   Electric.................................etc.
   Special..................................
g. Cupola chargers..................................Foundries

2. Transporting Devices (mainly for horizontal motion)
a. Wheelbarrows.....................................Yard work
b. Hand trucks
   Stevedore type...........................Shipping; freight
   Box type................................. Special service
   Rack type................................in manufacturing
   Platform type............................plants
c. Industrial railways and equipment (narrow gage)..Heavy handling
d. Tractors and trailers
   Electric.................................Mass movements of
   Gasoline.................................products
e. Tructractors.........................Rapid and severe service in
   manufacturing plants
f. Railroad equipment (standard)..............Transportation service
g. Car pullers..............................Spotting freight cars
h. Aerial tramways..........................Long distance conveying
i. Skids for rolling pipe, etc. ....Storing and Shipping
j. Pipe lines.......................................Fluids
k. Pumps..Fluids

3. Devices that both lift or lower, and transport (combined vertical and horizontal motion)

a. Chutes...Gravity handling
b. Hoists with trolleys running on overhead rails
   Chain..General service in
   Air..manufacturing plants
   Electric...

(continued)

3. Devices which both lift or lower and transport. (continued)

c. Lowerators..In conveyor systems
d. Lift trucks
    Hand...Rapid service on good
    Electric.....................................floors or roadways in all types of manufacturing plants.
e. Small crane trucks
    Electric.....................................Lifting and transporting
    Hand...fairly heavy loads
f. Portable elevators or tiering machines..Stacking service in store rooms
g. Auto trucks.........................Heavy trucking inside or outside a plant
h. Conveyors
    Apron...
    Bar...Bulk or package
    Barrel..materials accor-
    Belt..ding to specific
    Bucket..nature
    Pivoted bucket....................................
    Chain...Unit products
    Disc scraper or flight and drag................... Bulk materials
    Package...Unit or package products
    Portable
        Belt..Bulk materials
        Bucket..
        Roller..Unit parts or packages
    Pneumatic
        Suction ....Loose and light
        Pressure...................................... materials
    Roller type
        Gravity.......................................Unit or package
        Power driven..................................products
    Screw...Loose materials
    Slat..Unit products
    Spiral
        Chute...Unit or package
        Roller ....products

    Production line conveyors
        Assembly type (as used in the auto industry).....Machine and radio assembly, etc.
        Sacking type (as in cement mills) ....cement packing, etc.

i. Tramrail systems..................Handling units or assemblies in manufacturing plants.

j. Cranes
    Jib
        Hand..Local service
        Electric......................................on heavy shop work.

    Floor operated
        Hand ....Limited travel on
        Electric......................................heavy shop work

3. Devices which both lift or lower and transport (Continued)

Cranes (continued)
Gage operated
Monorail..Long distance
Bridge-overhead traveling.........................Traveling in shops
Gantry..and yards, loading
Ore...vessels and cars, usually on heavy work.
k. Locomotive cranes..........................Yard service in manufacturing plants, on construction, etc.
l. Car dumpers....................................Bulk shipments
m. Ramps..To give access to different levels
n. Trestles.......................................For storage of materials

This list gives a good idea of the equipment available but it must be remembered that there are variations of each type of equipment as well as new advances in the designs of the equipment every day.

This list gives some of the uses that the equipment can be put to, but no equipment should be bought or even selected until the engineering aspects of the application have been investigated. Qualified engineering advice should be sought before selecting any of the equipment.

It is usually possible to have equipment designed or modifications in design made to adapt the equipment to a situation. Though this usually is not a good practice, as it may lead to poorer performance, it should be kept in mind.

CHAPTER 3

PRINCIPLES OF MATERIALS HANDLING

There are no real formulas for the solution of a handling problem. There are formulas which can be used to determine which model or size of any one type of equipment will best suit the problem. That is, if one decides on a lift truck or screw conveyor, he can find formulas telling him which size lift truck or conveyor to pick, but there are no formulas which will tell one that a conveyor is better in a situation than an electric truck would be. Usually the correct choice is obvious, but in some cases, several factors have to be weighed in order to insure the correct choice.

As was stated before, the method offered by this paper and the one most generally suggested is for the person attacking the handling problem to become familiar with several so-called principles of materials handling, and along with the types of equipment available to effectively solve the problem. This paper does not go into the technical details of the operation of the equipment. It is advisable to obtain professional technical knowledge, about installation, operation, maintenance and other technical features. This can wait until the general types are decided upon.

Since almost every problem differs from the next, this method will allow the materials handling man to effectively solve the problem at hand. The principles will be common to many different problems even though the equipment chosen for each solution may be different.

For best results, handling problems should be solved in the original layout of the plant. The plant should be laid out so that there is a minimum of handling. If some handling devices are used, they should be made an integral part of the layout. This insures full utilization of the equipment and serves to cut handling cost to a minimum. If this were done for every

plant, one would raise the question of why the need for handling after the plant is laid out. The fact is that often times the processes change, or other factors change that necessitate a change in the layout or the re-routing of the material through the plant. For these reasons, handling problems are constantly occuring in industry.

In order to effectively cope with these problems, one should become "handling conscious" so to speak. Below are listed several principles which the handling man should keep in mind. They are those which we may call general principles, those which apply to the physical features of the plant, and finally, those which apply, in general, to all types of equipment selection and costs.

<u>Reduce handling wherever possible.</u>

Look over the problem. Make a model layout of the plant for studying the various materials handled. Take a sample lot and follow it through the plant noting every movement of it and just how much is moved. Then on the model layout, draw in or mark by string or yarn the paths the various materials follow through the plant. It is wise to have some means of showing elevations on the model. If the plant is multi-story, you can mount one floor on top of the other. This is good because then you can show vertical as well as horizontal movements. By mapping out the movements on a model, a much clearer picture of the prpblem may be obtained. It is often difficult for one to visualize the movements while in the plant, but a small model will give the whole picture at once and make detection of poor handling much easier.

In reducing handling, one should look for places:

1. Where re-handling takes place
2. Unnecessary transportation to and from one operation to the next.

3. Notice and eliminate back tracking.

4. Notice how close the material is brought to the actual point where the operation is to be performed.

5. Notice how much handling the operator has to perform.

It may be observed that it costsmore to load and unload than it does to actually tranport the goods. Sometimes the design of special trays and pallets will facilitate the elimination of re-handling. One plant was observed where a re-handling problem was solved in the following manner. The problem occurred in the store room. The store room had rows of shelves, one stacked on top of the other. They were permanent to the extent that each section, about four feet long and four or five shelves high, could not be taken apart. The sections could be moved though. When partscame into stock, they were placed on the various shelves according to the type of part. That is, like parts were placed on the same shelf. The various parts that were required for a sub-assembly were collected from the shelves and placed on a skid. The skid was then transported to the place of actual sub-assembly by a handlift truck. When the sub-assembly was completed, it was placed back on the skid and brought back to the store room. The sub-assembly was then taken off the skid and placed on a shelf. Like sub-assemblies were placed on the same shelf. The various sub-assemblies needed for a complete or final assembly were then collected from the shelves, placed on a skid and sent out to final assembly. Thus, we cansee that the materials were handled four distinct times; parts placed in stock, parts for sub-assemblies collected, sub-assemblies placed back in stock, and sub-assemblies collected for final assembly.

The solution to the problem was rather simple. Instead of using

the old storage shelves, new ones were purchased. These shelves were separate units but they could be stacked one on top of the other giving the same utilization of the upper space of the store room as before. With the new system, parts were placed on the shelves according to sub-assemblies. That is, when parts came in, they were not placed together but the various parts for a sub-assembly were placed on the same shelf. Then when sub-assembly wanted parts, the whole shelf was lifted out and taken directly to sub-assembly. The same procedure was followed when the sub-assemblies returned to stock so that for final assembly, the shelf was picked out and sent out.

With the new system, it can be seen that two of the four handlings were omitted. This not only saved handling expense, but also helped to determine how many parts were ready for assembly and sub-assembly. Before, parts had to be counted and sometimes there were shortages of parts, so that accurate estimates could not really be given until the supplies on several shelves were determined. More often than not, schemes like this may be devised to eliminate re-handling.

Much time is lost in handling when the goods to be worked on are not brought close enough to the actual workplace. The places where skids are placed near the machines should be examined to see if better placing will allow the worker to spend less time in picking up and putting down the piece he is working on. This applies as well, to the placement of conveyors and hoists, as skids. It is amazing the amount of time that is lostby workers collecting or reaching for the material to be worked on. Motion and time studies of the problem have determined that anywhere from 10% to 80% of the operators' time is spent in materials handling.(1) Good delivery of material

1. Alford, L. P., and Bangs, J. R. (Eds.), Production Handbook, Ronald Press, New York, 1944. Page 1015.

will also reduce fatigue upon the worker. When we consider the wages of skilled workmen as compared to the laborer (usual wage for those engaged in handling), then we can see how important it is to cut down the time spent by the operator on handling.

Sometimes one can readily see unnecessary movements of the materials just by glancing at the model layout. Often times there is no reason for them. Sometimes they occur because the driver of a truck just has a habit of going a certain way. Other times the worker has no idea of the shortest way to a certain point in the factory. By instructing the worker, this may be eliminated. Make out a route for him to follow and tell him what it is.

If back-tracking is noticed in the movement of the material through the plant, it is well to try and see if the operations can be performed on the work in a different sequence which will eliminate the back-tracking.

Travel a minimum distance.

This principle is closely anologous to the previous one. It pertains more, of course, to the actual transportation of the goods through the plant. Rearrangement of shipping platforms and store rooms will often times tend to cut down the distance traveled to a minimum. The best way to cut down travel to a minimum distance is held in the next principle.

Travel in straight line movements as much as possible.

It is a well proven fact that the shortest distance between two points is a straight line. With this in mind, look over the model

layout of the plant and note the changes of direction that the materials make in their journey through the plant. Note where the material starts from and where it is to go. Draw in a straight line and note how closely you can approximate it. One must remember that corners slow down truckers and also add hazards. By straight line is not meant that goods should start at one end of the plant and go straight through to completion at the other end, although this is often the best method. Goods may start up the plant in a straight line and then come down another aisle. Goods should never be completed in the center of the plant or some obscure corner, but in such a position that they may easily flow through to the shipping room to the shipping platform.

Provision for flexibility.

It should be remembered at all times that handling adds nothing to the value of the product. It is a means of facilitating production. For this reason, we should make sure that handling never slows down production. In a highly mechanized plant, one can easily see that if one piece of handling equipment, such as a conveyor, breaks down then it often delays work for a hundred or more men. The company usually has to pay these men whether they have work before them or not. A delay of only ten to twenty minutes can add up to a considerable sum if one considers the combined wages of the men out of work. For this reason, the system of handling should be flexible to some extent. Other means of handling, usually more primitive such as hand movements, should be ready at a moment's notice to keep the men working.

One company visited by the author, and this is the practice with many others, provides for breakdowns in the handling equipment by

constant inspection and changing of worn parts or belts on the off shifts. They have strategically located stocks of spare parts throughout the plant to aid in the replacement of worn or broken parts. This method is often times successful if those concerned know the points of greatest difficulty and wear in the system. It often times takes a little while and a few mistakes to make the system operate effectively.

Another reason for providing for flexibility, and perhaps a more important one, is that very often the plant layout or products are changed. Sometimes this is predictable, but more often than not due to competition, substitute materials or war plants have to do some rapid revising. Handling equipment should be flexible enough to adapt itself to the new situation. Some people go so far as to advocate the use of portable equipment wherever possible because it can be moved and adapted more readily to a new situation. This may be good in some cases, but the best method is to provide for economical and efficient handling in the situation at hand and then go into the problem of flexibility. Portable instead of fixed equipment may be put in only after it is determined that it will not hinder the effectiveness of the system.

<u>Choose equipment for lowest operating costs</u>.

In selecting equipment for any handling job, many people have the idea that the best thing to do is find the cheapest equipment to do the job since handling is secondary to actual production, but they forget that operating costs are more important than the original cost of the equipment. Equipment should be selected for lowest operating costs. In choosing for lowest operating costs, one must remember that cheap equipment often times breaks down. These breakdowns result in very high

maintenance costs which tend to more than nullify the original purchase price saving.

Usually the price of handling equipment is written off within two or three years and then all that is left is the operating expenses. Even if longer is taken in writing off the purchase price, the amount written off each year is considerably less than the operating charges. Usually the equipment lasts about fifteen or twenty years.

Select equipment with an outlook for the future.

Most every industrial plant makes some provision for future expansion or increased capacity. Handling equipment should be selected with the future program for the plant in mind. The handling system installed should be able to handle the output of all the machines already installed and those machines to be installed in the future. The reason for selecting equipment with an outlook for the future is simple. It costs more to make improvisions to increase the capacity of the handling equipment than it does to have the system put in originally to take care of the increased load. Of course, if the increase is not planned until some far distant date, it might not be too wise to do this, but for the plant planning expansion soon or operating at varying capacities, it is best.

Safety for the workers should be provided.

In any installation, safety for the operator or the workmen should be provided. Overhead installations should be located so as to not cause a hazard to the men. Aisle width should be sufficient for trucking. Blind corners should be eliminated and helpful warnings should be posted. Most of the equipment on sale does have safety

features for the operators but nevertheless, the equipment should be inspected for these before it is put in operation.

An interesting note is a recent strike which was called in a wholesale warehouse. The main reason for the strike was that new trucks were putting men out of work. One of the demands was that with electric lift trucks, it was dangerous for one operator to handle a truck alone because there were blind corners where the trucker might meet with an accident. His vision might be impaired if the load were up in the air. Adequate provision for safety will often times cut down labor unrest, to say nothing of the costs resulting from accidents. If new equipment is installed and the first thing that happens is an accident, then the workmen will not have much faith in the new system which may hinder its effectiveness.

Never allow overflows or pile-ups.

An efficient handling system should enable the materials to flow through the plant in an orderly and efficient manner. The capacities of all the machines to be served by the equipment should be taken into consideration. Provision should be made for taking care of all the output of the various machines. The various parts of the system should be well coordinated so as to eliminate the possibility of pile-ups which cause slow-downs and often times shutdowns.

One plant had an experience during the war which illustrates this point well. A contract to machine several thousand parts for shells was accepted and the machines provided. The space in which the machines could be placed was limited but it seemed to all concerned that there was sufficient room. When the plant got in full operation, it was

found that the machines were producing so much so rapidly that they were not only unable to handle the finished parts, but were unable to carry away the shavings. Adequate thought and planning for the operation would have avoided this, but due to the urgency of the situation, there was no time for this. The problem was solved by using greater floor space. The machines were placed farther apart, more piling space allowed, and increased trucking facilities allotted.

<u>The investment should be justified by the return.</u>

The investment in handling equipment should be considered the same as an investment in any other type of machinery for the plant. With a machine tool the investment and return can be compared with the previous machine used for the job. The same is true of handling equipment. The initial cost along with the operating cost,can be compared with the previous method used to give some sort of financial comparison. There are many intangibles that cannot be accurately ascertained, such as the increased production due to the cutting of lost time on the part of the workmen either in waiting for the material to work on or spent in reaching for and transporting the material. These factors should be weighed in when one considers the return on the investment in handling equipment.

The <u>Production Handbook</u>[1] has a formula for determining the economies of materials handling equipment, but it will not be reproduced here as it is quite long. In order to give a picture of what factors should be taken into account in figuring the savings of handling equipment, some of them will be gone over. The formulas are good for

1. Ronald Press, New York, 1947. Page 1025.

determining the maximum investment in dollars justified, the annual cost of owning the equipment in condition for ready operation and the annual profit from the operation off the equipment. The factors that have to be taken into consideration are return on investment, insurance, taxes, upkeep, depreciation, obsolescence, power, supplies, savings in direct labor, savings in overhead, savings through increased production, time equipment will be in use, and the initial cost of the equipment. These factors, as can be seen, give the savings and the expenses brought about by the use of the new equipment. The savings are balanced against the expenses giving justification for the installment of handling equipment. Some factors, such as savings in direct labor through reduction of handling time on the part of the operator, are difficult to determine especially before the equipment is put in use but they should not be forgotten.

Utilize the equipment as fully as possible.

Many authors call this the principle of reducing terminal time or idle time. These are both the same. It is common sense that the greatest economy is gained from a piece of equipment if it is kept in use as much as possible.

With a company using electric trucks to a great extent, there is a chance for great savings if they head this principle. Many times electric trucks spend a good portion of their day either being loaded or unloaded. In reality, the equipment is not in use. It is just acting as a temporary storage place for the goods while they are being unloaded. The use of pallets which can be picked up and placed

down anywhere without necessitating the truck to stand by idle is one solution to the problem. Also the use of trailers serve as a good solution. One electric truck can haul as many as eight or ten of these trailers. The trailers are much cheaper than a truck and can be placed around the plant to be loaded and unloaded without tying up the truck. By using these means, the number of trucks required to transport the required material is much less.

Standardize equipment and methods.

An important feature of any handling system is that the methods and equipment should be standardized. That is, the means by which each type of material is to be moved should be known to all concerned. Sufficient pallets and trucks of the correct size should be provided. A definite schedule or route for the picking up and transporting of the goods should be provided.

By standardization, great economies are effected. This idea of standardization applies not only to the equipment, pallets and methods of one plant or separate plants, but to industry in general. The producers of handling equipment offer a wide variety of equipment. Some of the types vary so little from one another that the difference is negligible. If the equipment types and variations could be cut down and a few models standardized upon, there would be more economical production of the equipment and this saving would eventually be passed along to the purchaser, in part, at least. This would afford savings in the outlay for handling equipment.

Standardization of the equipment throughout the plant

facilitates the training of the workers who operate the equipment. It also decreases the expense of maintenance. Parts for the equipment may be stocked easily. Not so much money will have to be tied up in accounts with various suppliers and mechanics will have an easier time repairing the equipment if they do not have to stop and decide just what type it is and how it works.

Perhaps one of the most widely used handling devices is the pallet. These are usually of various sizes depending upon the needs of service. Standardization of the pallet sizes has taken place to a large extent. This has been mostly in warehousing or packaging industries. Packages are designed to enable one to effectively load the pallets. The pallets are designed so that they may be placed or stacked in freight cars so as to utilize the maximum amount of space available. The only trouble is that the railroads have placed a shipping charge on the pallets which makes continued use of them rather expensive. That is, a freight charge is made on the weight of the pallet. The rate also applies when they are shipped back to the point of original shipment. There has been a suggestion that with standard pallet sizes, a pallet pool could be set up in the principal cities where pallets may be taken after the car is unloaded. Other firms could use them for shipments out of the particular city thus eliminating the extra freight charge for returning the pallets to the original shipper. Each shipper would receive credit for the pallets in the pool with which he could secure other pallets in his own city.

Standardization also applies to the packaging. If packages were standardized to a greater extent, then more economical

production of equipment designed to take care of these could be produced. Standardization of packaging and containers coming into the plants should also be considered. On any orders, it is wise for the handling man to have a say in how the material should be packaged or contained so as to have the package fit the handling equipment.

Increase the unit loads.

This principle is more or less common sense. Since so much time is wasted in loading and unloading, one can easily see that it takes longer to load fifty small cartons on a skid than it does to load five larger ones containing the same amount of material.

It is common sense also that it is cheaper and quicker to have one larger truck handling five times as much as a smaller one to do a job, than have five smaller ones using power and requiring more labor to make five trips.

Since any solution to the handling problem must be adapted tc the plant and the actual material handled, there are many details about the actual material and the physical features of the plant that should be taken into account. Even technical advice will be of little value unless certain facts about the material and plant are made know first.

Below are listed those additional factors which should be known and taken into account.

Know the floor surfaces.

Whenever one decides upon using electric trucks as a means of handling, he must remember that the floor surfaces may be a limiting factor. Many times floors in the plants are in bad condition.

Perhaps there are cracks that would have to be fixed before the trucks could run over the floors easily and safely. Some floor surfaces are liable to wear under the wheels of the trucks. If the trucks take the same route every time, the wearing might lead to larger maintenance costs. If you tell the truck manufacturer just what type of floor the trucks are to pass over, he can often times equip your truck with either rubber or steel wheels depending upon which he thinks best. He usually has more information on the equipment than the individual user. Complaints and recommended design changes from the users give him a broad picture of operating problems under almost any conditions.

Sometimes one can place metal plates along the aisles that the trucks are to run down. This gets away from the necessity of changing the means or the floor surface.

Know the building stresses.

A perfect solution to a handling problem may be worked out and the equipment purchased only to find that due to an oversight, the building cannot withstand some of the stresses the system would put on it. In order to have the system work properly, it sometimes costs more to repair the building than to purchase the equipment. Thus, a system which at first seemed financially justifiable has become an extravagant proposition.

If the stresses that the building can withstand are known beforehand, then an impossible solution to the problem will be avoided. Always seek engineering advice as to the technical possibilities of the system. This paper does not advocate that only those with engineering background are capable of dealing with handling problems. It

does advocate that the person dealing with the problem have some idea as to when he sould seek technical advice.

Know the material to be handled.

This is one of the most important facts to keep in mind whenever attempting a solution to a handling problem. One of the requisites of handling is to get the material to the right place at the right time, in sufficient quantity and in the correct form or state. Sometimes improper selection of handling equipment to do the job will result in damage to the material. Too rapid translation of the material may result in damage. It may mean that when stopping, starting or loading, the material is crushed or damaged. Chutes which are too steep often result in crushing the packages or containers.

Another important reason for knowing the qualities of the material is so that equipment will not be chosen which the material might damage. To illustrate, take coal or coke as the material. A conveyor belt is usually the best means but if one is selected in which the driving mechanism and rollers are not enclosed, the user will find that fine dust particles from the coke or coal will get into the mechanism and make repair and maintenance costs excessive.

In the book, Conveyors and Related Equipment, by Wilbur G. Hudson,[1] there is a good selection chart for selecting equipment to handle abrasive materials. Though the book is written for engineers, it does not take an engineer to use the chart. Whenever purchasing equipment, the buyer should specify what use he wishes to put it to in case

1. New York, John Wiley and Sons, 1944.

the seller might be able to point out a difficulty. Some sellers will try to sell even though they know the equipment might not be the best suited for the use to which it is going to be put. It is good to specify in the purchase order what you wish it to do in order to be on the safe side. Then if the equipment does not live up to its specifications, there is a basis for legal action.

<u>Know the amounts to be handled including the size shape and weight.</u>

It is not necessary for the person suggesting the solution to the problem to know how to figure which size belt or size of buckets on a bucket elevator to order. It is necessary for him to determine exactly just how much is to be handled by the means decided upon. If this information is given to an engineer, then it is a simple matter for him to determine the correct size of belt to purchase. The size, shape and weight will also enable the engineer to make a better selection. The stress and strains that the uneducated eye misses can all be taken into account if a complete description of the material to be handled is furnished.

Along with specifying the conditions and physical features of the material, it is wise to specify how you wish purchased material delivered. Standardize the form that your purchases should be delivered in. This helps to insure the effectiveness of the installation.

Finally, there are some thoughts to keep in mind about the actual equipment decided upon to do the job. Again these are general in nature and do not tax the technical knowledge of the individuals.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Choose proven equipment whenever possible.

This is really only common sense but it is surprising sometimes how people devise new pieces of equipment to do a job only to find out it is impractical. By sticking only to proven equipment, the user benefits from the accumulated knowledge of years of use which has been built into the equipment. The user knows that he will be able to get parts and service in case of breakdowns, to replace the equipment when it is worn out and also, obtain a better value for the old equipment when trading it in for a new model.

Repair and Maintenance.

The repair and maintenance costs of the various types of equipment should be looked into. By visiting other users of the same type of equipment, it is possible to find out how much this expense will run. The seller may claim it is negligible, but in order to be on the safe side, it is best to consult a user.

The best way to insure a low repair and maintenance charge is to follow the above principle of selecting only proven equipment. It is only natural that continued use of a certain type will point out the flaws in it and these can be corrected in the design. Since initial cost is not as important as operating costs, it is wise to weigh the repair and maintenance factor heavily when selecting equipment.

Use the lowest type of equipment.

By this is meant that it is senseless to use a power conveyor when a gravity roller could be used or to use an elevator when a chute could be used to do the same job. The simplest solutions are

always the best. If one can use a simple gravity conveyor instead of a power-driven one, then he not only cuts down the operating expense but also cuts down the possibilities of breakdowns. A complicated system cannot be understood as simply by those using it as a simple one. It is easier to make changes in the system when production warrants it. Complicated systems usually involve special purpose machinery which cannot be easily adapted to a new situation.

Know the life of the equipment.

One might say that if handling systems have to be changed so often, then what is the value of buying equipment that will last for fifteen or twenty years. The reason that the equipment can usually be used no matter what the setup, should be reason enough for investigating the life of the equipment. Usually the cost of the equipment is written off as soon as possible, but more often than not the equipment is used for fifteen or twenty years. A piece of equipment designed for short usage usually means that the repair and maintenance costs will mount faster than one designed for longer usage. It is hard to determine just how long you will wish the equipment to last when buying, so it is wise to buy a type that will last at least ten or fifteen years. The cost difference is negligible and will be well worth it in the long run. It may be that the system will not have to be changed for twenty years.

If the person attacking the handling problem follows the principles outlined above, he should be able to work out an effective solution to the problem. It will not only be an effective solution, but the correct or best solution. By comparing the different methods on these principles, he can determine the one best way.

As was stated at the beginning of the chapter, these principles can be applied to any situation. In order to illustrate this point and show how they can actually be used in solving a specific problem, we will take the case of remodeling a foundry. The foundry will serve not only to illustrate the point but also to give the reader an idea of how big a factor handling is in industry.

The following two chapters will concern themselves with a description of the foundry before it was remodeled, and then a description of the foundry remodeled. The reasons for the original layout and the changes will be explained which will give the reader an idea of how the principles are really applied in practice.

CHAPTER 4

A FOUNDRY WITH POOR HANDLING (1)

In the first chapter it was stated that handling often constitutes a great portion of the total manufacturing process. One type of industry where this is especially true is in foundry work. When it is realized that for every ton of finished castings fifty to one hundred or more tons of materials have to be handled, one can see that handling is a large part of foundry work. In casting lighter metals this is not so true but with iron and steel foundries it might be considered an understatement.

By studying a foundry with poor handling and then studying the modernization of it, it is hoped that the foregoing principles may be illustrated more clearly.

The Chapman Valve Company has several foundries at Indian Orchard, Massachusetts. Most of these are modern installations but one iron foundry was over forty years old. Very few changes had been made in the operation of the foundry since it was built. In its day it was considered a good foundry but with time the installation had become outmoded. With the advent of the post war period, the company had a large production program to meet. New foundries could be built but besides being rather expensive it would also take quite a while. It was decided that they could improve the operation of the old iron foundry and obtain increased production. So the iron foundry was singled out for remodeling.

In order to understand the problem better and give back-

1. Material obtained from G.F.Fox, Chapman Valve Co., Indian Orchard, Mass.

ground for understanding the reasoning behind the changes instituted in the remodeled foundry, the layout and operation of the foundry will be explained.

The foundry building was about 250' long by 150' wide. The building was divided into three bays which for convenience we will call the east, west and middle bay. If one follows the diagram of the foundry, he will find it easier to understand the operation of the foundry.

In this foundry cast iron valves of very small size up to the larger ones, often weighing tons, were made. The larger ones were made in the center bay and the smaller ones were made in the two side bays. The smaller and medium sized valves which were more or less standard were produced in the side bays. The operation in both side bays was similar so that a description of one bay will serve to show hoe the operations were performed.

Along the west wall of the foundry several molding machines were located at intervals of about twenty feet. Two men worked with each machine. The work was on a piece work basis. That is, each group of two molders had a certain amount of finished castings to produce each day. They worked independently of the other groups. There usually were about twelve groups located along the wall.

Since the operation of each group was similar, a description of one team will serve to explain the operation. Each group was responsible for the sand it used. They cut and mised their own sand. In the morning the two molders came to work and their sand was piled up near the molding machine. The flasks were piled up near the machine.

One of the men picked up a drag and placed it over the pattern which was on the table of the molding machine. The other man set the flask and picked up a sieve into which the first man shoveled some of the sand which was on the floor. The screened sand was spread over the pattern. This was necessary because fine sand near the pattern would insure a smooth surface on the finished casting. After the pattern was covered, more sand from the floor was placed in the flask and rammed by hand. The flask was heaped with sand and a hydraulic mechanism pressed the rest of the sand securely in place. The drag was lifted off the pattern and the cope was made up in the same manner.

If there was a core to be placed, this was placed in and the cope placed on top of the drag. Depending upon how much the finished flask weighed, it was either carried by one of the molders or by an overhead traveling hoist arrangement to a space on the floor between the molding machine and the aisle separating the west bay from the center bay. The flasks were placed on the floor in rows extending from the machine out to the aisle. Since most of the flasks weighed about fifty pounds, they were carried by hand an average distance of twenty feet from the molding machine to the space on the floor. The hoist and overhead trolley arrangement was such that the flasks could be picked up and placed down anywhere in the area. The flasks were also poured in this area and the hoist was used to carry the pouring ladles. Each molder group worked all morning filling the flasks. By one or two o'clock in the afternoon the required number of molds were ready for pouring. The cupola was located on the north end of the west bay. Since pouring was done only once a day the furnaces

were started in the morning and the required amount of metal was ready by early afternoon.

The pouring operation was as follows. Several one ton ladles were used. They were filled at the cupola and carried to the various molders places by means of a monorail. The rail ran out from the cupola to a switch. Here the ladles could be switched to either a monorail running down the west bay or another one going down the east bay.

The ladle when it arrived at a specific molder's station was taken off the monorail by a hoist supported overhead by an arrangement which enabled the molders to move the ladle anywhere over the flasks. The two molders poured the metal into the molds by tilting the ladle. The ladle was equipped with a long handle which facilitated the tilting of the ladle. The empty ladles were taken back to the cupola for the next day's pour by the same monorail.

The flasks were allowed to cool for about an hour. In this time the shifts at the plant changed and a clean crewcame on. It was the job of the clean-up men to shake out the flasks, collect and stack the finished castings on skids to be taken to the cleaning room, and to re-work and prepare the sand for the next day's operation. This work was practically all done byhand labor.

The workers first, with the aid of the same hoist which was used for pouring, shook out every one of the flasks allowing the sand and casting to fall on the floor. The casting was picked out of the sand and placed on a skid for future transportation to the cleaning room. An electric truck carried the skids there. The floor was made

of wooden blocks. The picking up and placing of the castings was done by hand and involved carr ing about 25 pounds an average distance of ten feet.

The flasks, both cope and drag, were collected and stacked near the molding machine. This, too, required more hand labor. When this had been done, the sand was then taken care of. The sand was shoveled into an oblong pile by the two men. While doing this the sand was also sifted to separate the metal scrap from it. Then the men cut and mixed the sand for the next day's work. This operation required quite a bit of hand work also.

In summarizing the operation of the west bay we can say that it took two men working an eight hour shift to put out anywhere from twenty-five to seventy-five castings depending upon the weight. It also required two more men to clean up and re-work the sand. It must be remembered that the whole operation required a great deal of hand labor.

The operation in the east bay was similar to the west bay but the center bay was a little different. In the center bay the castings of a larger size were produced. These larger valves were not produced in as great a quantity as the smaller ones. Production here was more or less on a job order basis. The flasks were so large that an overhead traveling crane handled them. This was also true of the cores. Sometimes it took days to make up the flasks and for this reason the operation here was more or less irregular. The flasks, cores and ladles were handled by the crane. The finished casting was carried by the crane to the north end of the building where they were shaken out.

New sand wasbrought back from here and the operation started over again.

The cores used in the system were made at two locations. They were either made in the north end of the foundry, where ovens were located for the baking of the cores, or in another foundry where there were core blowing machines whose total capacity was not utilized for that foundry. The cores, no matter where they were made, were distributed to the molders at their various stations throughout the foundry by electric trucks. The truck would pick up a skid loaded with enough cores for one group of molders and deliver it. The average round trip distance for the delivery within the foundry was 250 feet. The reasons for the layout and operation of the foundry were quite logical forty years ago but with time they seemed ridiculous. It must be remembered that forty years ago labor cost fifteen cents per hour. The disparity between equipment costs and labor costs was much greater than it is now. Today with labor costing from one dollar and fifteen cents upward, and with overhead costs added onto this making the total cost for labor per hour upwards of five dollars, one can see how important it is to do away with any excess or waste of human effort. But forty years ago it was not expensive to have the castings lugged around the foundry.

In the past there was also a greater pride in ones job. If one was a molder, that meant that he could make up a flask, work his own sand, pour his own flasks and oftentimes make his own patterns. The workers took greater pride in the finished product and tried to put as much of the human element into it as possible.

The foundry was laid out before the days of the mass production. The economies of standardization, simplification and mass output had not been fully realized. As can be seen the foundry was broken up into small operating units. When this is done, much duplication of effort results. In this case over twenty-five different piles of sand had to be worked. Centralized sand conditioning would have eliminated this duplication of effort.

Of course much of the process has become obsolete due to new equipment in the field. It takes time to develop new equipment and with the development of some equipment it was put in use in the foundry as soon as it proved practical, but many new developments could not be used without re-modeling the whole plant. After forty years there were many new advancements in use that had rendered this foundry impossible of economical production.

Looking over this layout there are many examples of poor handling. The first and by far the most important is the sand handling. There are over twenty piles of sand that have to be worked separately. This necessitates the employment of many men to work the sand so that it may be ready in time for the next day's work. Due to the decentralization of the sand new sand, which has to be mixed with the old, cannot be delivered economically. Small amounts of sand have to be brought by electric truck to twenty different locations. A belt cannot be used with any reasonable saving. With sand decentralized there is much duplication of effort. If the sand were located at one spot then equipment for working large amounts of it might be installed with the resulting saving in labor.

Another difficulty with the layout is that there is a great deal of space used for storage. The finished flasks take up a great percentage of the space while there are stores temporarily on the floor preparatory to being poured. Much space is used in the storage of the sand at the molder's stations. When a great deal of the space is used for storage, the productivity per unit of area is greatly reduced.

With the activity of the foundry divided up as it is, handling is made more expenseive from an equipment view point. That is each molder's station is provided with a hoist. The hoists are used only a small portion of the time and the rest of the time they are just adding to the overhead cost. It must be remembered that for greatest economy the equipment should be utilized as fully as possible,

Another fault with this system is that it has skilled men spending a good percentage of their time handling. As an example, we can take the molders. They have to shovel the sand from the floor to the flask instead of having it in a hopper where it could be dumped into the flask by the manipulation of a lever. The molders also spend their time carrying the flasks from the molding m chine to their place on the floor preparatory to pouring. Thus, instead of getting the most for the wages paid, molders wagers are being paid for handling jobs to say nothing of the lost production on the part of the molder.

As for any semblance of straight line movement in the plant, there is very little. In the center bay all the flasks, sand and metal are brought up to the place where the mold is to be made and then the finished flask is brought back to the end of the foundry to be

shaken out. Then the operation starts all over again with the same materials being transported back up to the other end of the foundry. In the side bays there is the flow of finished castings from all directions. Electric trucks and overhead cranes make several trips over the same route to take care of the production. The molten metal has to travel three or four different routes. This necessitates much extra equipment. It means that a system of monorails has to be kept so as to get the metal to almost any part of the foundry. The main trouble with the whole layout is that the material has to be handled in small lots. Sand, molten metal and finished castings are handled in small lots and this does not lead to economy. Cores, for instance, have to be delivered in small lots to each molder's station which means many trips with an electric truck, carrying a skid of cores. Each trip meaning the transportation of a small amount. The trucks could be loaded with enough cores for three or four molders but this would mean that there would be much re-handling. The truck would have to be unloaded at each station. The only solution to the problem is to rearrange the layout so that functions are more centralized. This would enable bigger more economical loads to be carried. It would mean the cutting out of much duplication of effort.

In the following chapter the solution decided upon will be described.

CHAPTER 5

MODERNIZATION OF THE FOUNDRY [1]

In modernizing the old foundry there were many decisions to be made before any remodeling could take place. Due to the pressing demand for finished castings, it was decided inadvisable to shut down the whole foundry while the remodeling took place. For this reason and one other, it was decided to remodel the foundry in parts. Plans were drawn for the whole job but they were drawn so that one part could be remodeled without interfering with the rest of the foundry. The other reason for remodeling by steps was that it would be easier to work out the inevitable bugs in the system. No matter how well a purposed change is laid out, there are bound to be some flaws in it that can only be solved or worked out when the plan is in actual operation. There are also parts of a plan that it pays well to wait and solve, for the reason that often times parts which one considers will work perfectly, may, when in actual use, not live up to expectation. These parts may affect others and for this reason, some parts of the remodeling were left until the plan was in actual operation. Ideas as to how to solve these difficulties were, of course, kept in mind and the solution was delayed to see which one would suit the situation best.

Since it was desirable to obtain greater production with a new layout and more efficient handling of the various materials that are necessary, a decision had to be made as to how to divide up the work in the foundry so that the plant could be laid out with some idea of just what

1. Information obtained from G. E. Fox, Chapman Valve Co., Indian Orchard, Mass.

had to be done, when and just what had to be handled to do the job. As was stated before, castings from the small type up to the larger type weighing tons or more were made in the foundry. Many of the smaller valves were more or less standard, as well as many of the medium sized ones.

The types of valves were divided into three classes:

1. The smaller ones below two inches.
2. The medium sized ones between two inches and twelve inches.
3. The larger ones above twelve inches.

There was a good volume of production on most of the medium sized ones. Those with a good volume in this size were selected and it was decided that these could be produced in the west bay. With this in mind, there was a starting point for those in charge of remodeling for they knew just what was to be produced and about how much material had to be handled for each unit of production.

With this in mind, they decided that to get any real production of the west bay, some standardization should take place so that the equipment could be designed and laid out for efficient operation. The first thing that was standardized was the size of the flask that would be used to contain the molds for the necessary valves. It was clear that the flask should be large enough to take care of the largest valves to be made in that bay (12"). It was found that the flask size previously used for the twelve inch valves could be used and that the smaller valves could be doubled up in the larger flask. Three or four, sometimes more, smaller valves could be made in the twelve inch

size flask. Standardizing on this size was also advantageous because there were some of that size flask already in use in the foundry. Since the flasks were made at the plant, there would be no difficulty in obtaining more of the same size.

With the size of the flask determined, they had an idea of what the equipment should be designed for. There was some other equipment on hand at the foundry which could be used in the remodeled foundry. This equipment came from a dismantled steel foundry and was:

(1) A sand conditioning unit consisting of:

a. Elevator discharging to either of two cylindrical screens over a sand bin.

b. A traveling measuring hopper.

c. Two Simpson sand mills.

d. A milled sand storage bin with an apron feeder under.

(2) An apron feeder and hopper for use from shake-out.

(3) A 24" x 12" belt conveyor with a magnetic pulley, (Pulley could be detached and used elsewhere).

(4) Some of the flasks standardized upon.

The fact that this equipment was on hand did not mean that it was imperative that it be used in the new setup, but it did offer a means of savings if it could be used.

It was realized that increased production could not be obtained with pouring once a day, as this meant that much of the space in the foundry would be taken up with temporary storage of the molds as was the case before. It was decided that continuous pouring would have

to be obtained. This meant that there would have to be some steady flow of finished molds, pouring and shake-out.

By far the most important material to be handled was the sand. Great quantities of sand were required if any reasonable production was to be obtained. In Exhibit 4 is a layout of the sand handling and the sand conditioning unit. It must be remembered that this is in the west bay which constitutes about one-third of the total floor space of the foundry. The other two bays which were being left until after the west bay was remodeled were to obtain about the same layout except that the center bay would require heavier equipment as that was where the larger castings were to be made. Due to the fact that the other two bays may be modified when the west bay gets in operation and to simplify the discussion, only the west bay will be studied. One should just keep in mind that the other bays will be similar.

Getting back to the sand handling equipment in the west bay, the requirements for the sand may be used as a starting point. The sand should be uniform in consistency and ample amounts should be supplied to the molders. This sounds simple, but one must remember that this meant that the scrap should be taken out of the sand after shake-out, the sand must be broken up into a fine condition, it must be cooled and any mixing of new sand or water must take place before the sand may be used over again.

It was determined from past records that it would take about fifty minutes for a flask containing the twelve inch size valve to cool. (After a flask is poured, it requires some time for it to cool before it can be broken open.) The smaller valves would, of course, take

less time, but since there would usually be at least one twelve inch size valve being made every hour, then any conveying means that was decided upon would have to be regulated for a fifty minute cycle between pouring and shake-out. Thus they knew that one cycle of forming, pouring and shake-out would take about fifty minutes. This fact was important in the determination of the sand requirements. The time for the flask to cool was the longest part of the operation so the management knew that after it was cooled, they could shake it out and use the flask over again. The other limiting factor was how many flasks could be made up in the fifty minutes. It was found that the molders could make up about one a minute. Thus they decided that they would use about fifty or sixty flasks an hour. The flask size was determined beforehand. The dimensions decided upon were 29" x 29" x 12". Both cope and drag were this size. By taking the volume of the flask and multiplying it by the weight of sand per cubic foot and then multiplying this figure by sixty, the sand requirement was determined to be about fifty tons per hour. In order to be on the safe side in case production could be speeded up, the sand handling and milling equipment was designed for sixty-five tons per hour.

The first requirement then was to have sand mills which could mill sixty-five tons per hour. It was determined that three sand mills could take care of the required production and provided sufficient storage of sand. The sand could be either milled as the days work went along or could be milled during the night when the requirements for it were nil.

It might be helpful to state here that all the equipment

including the sand mills were designed for sixteen hours production a day. This was in case sometime in the future it might become necessary to increase production substantially. In case of war, this would be very important. By having the equipment designed for sixteen hours' service a day, the possibility of greatly added expense in case of increased production was eliminated. The cost difference was little. More durable equipment was purchased.

For reasons of economy, it was decided that all the filling of the flasks be done in the same place. It will be remembered that before the filling was done in several locations which led to much duplication of effort and precluded the possibility of installing handling equipment to serve each molder as the expense would run too great. The pouring and shaking out would also be centralized. The reason for this is easy to see when one considers that with everything centralized, then the equipment can be designed to carry bigger loads. They knew where the material was to go and how much was required. This meant that the handling, sand handling, equipment could be designed and made an integral part of the system which is considered the best way. The decision to do this cut out practically all the handling which was performed in the previous method.

In another foundry of the same concern, there was a modern installation. In this installation, a turntable arrangement was employed. On the table the molds were filled and the cores set. This worked well and for this reason, it was decided to use the same method in the new foundry. To eliminate the amount of time spent by the molders in filling the flasks with sand, it was decided to use a sand slinger. This piece

of equipment shoots the sand out of a nozzle at a rapid rate. The nozzle can be directed in any direction. The speed or velocity of the sand leaving the nozzle does away with the necessity of packing the sand in the molds.

With this in mind, we can now consider the handling of the conditioned sand. Sand reconditioning will be explained later. The conditioned sand had to travel from the sand mills to the stationery sand slinger at the turntable.(1) The sand mills were large and it was deemed unadvisable to have them located within the plant as they would take up too much room. They were located outside along the south end wall. The sand slinger was located as close to the end wall as possible. The reason for locating it close to the mill was that it would reduce the handling. The problem was conveying a steady amount of sand from the mills to the sand slinger. The sand slinger could be loaded from either the top or the bottom. An elevator arrangement could be obtained with it that enabled one to load it from the bottom. It was decided to run a new 24" belt conveyor from the hopper under the sand mill to the underneath part of the sand slinger. The reason for this was that to run it overhead meant that it would have to go over the turntable or else take a roundabout route to get to the sand slinger. It was imperative that some arrangement of overhead cranes and hoists be located over the turntable for the setting of the cores (some weighing several hundred pounds) and also for placing the cope on top of the drag and finally for lifting the finished flask of the turn table and onto some sort of conveying mechanism. The height of the building was not too great at the

1. Refer to Exhibits 2 and 3.

point where the turntable was to be located so the table was made flush with the floor. This meant that some excavation would have to be done to make room for the base and driving mechanism of the turntable. While excavation for the turntable was being done, an extra trench was dug for the conditioned sand belt to run in. The conveyor belt was selected because it offered a very effective means of conveying a steady flow of sand to the sand slinger. The conveyor was troughed so as to enable it to carry more sand without spilling. The speed of the belt was variable to keep the supply of sand in synchronism with the needs. Under the hopper, an apron conveyor was placed because it could better withstand the sudden impact of the sand falling on it. (An explanation of the apron conveyor will be given in the reclaimed sand process.) The apron conveyor emptied onto the belt going to shake-out.

Thus, the conditioned sand went from the mills on a belt to the sand slinger and was placed around the pattern in the flask.

After pouring, cooling and shake-out, the sand would have to be reclaimed again. In order to cut down the distance that the sand would have to be transported after shake-out, it was decided to have the shake-out as close to the sand mills as possible. Of course, there would have to be a fifty minute delay after pouring before the flasks could be shaken out. With these things in mind, it was decided to have a pallet conveyor arranged so as to take the flasks when they came off the turntable, carrying them past the pouring section, and then return them back to the shake-out after the required time for cooling had elapsed. This pallet conveyor (as is shown in the diagram) started at the turntable and went down through the foundry where it turned and headed back to the turntable. Almost as soon as the flasks left the

table they were poured. This would enable a maximum amount of time for cooling. No time was lost between filling the flasks and pouring. The flasks then continued down the plant and returned. When they reached a point back near the sand slinger, they were lifted off the conveyor and shake-out took place.

In shaking out, the sand has to be emptied out of the flask and the casting picked out. The operation at the shake-out point was this. The flasks were picked off the pallet conveyor by a man operating an electric hoist. The hoist was on a monorail so that the flask was moved along to the shake-out grate. There it was placed on the grate and the action of the grate was such that the sand was shaken out of the flask. The casting was picked out and placed on a truck or in a metal container. The sand from the flask fell down onto a conveyor.

At this point, a description of the sand reclamation may be started. An apron conveyor was located under the shake-out and caught the sand as it fell. An apron conveyor is one made up of a series of metal plates on a chain arrangement. The plates are so arranged that they form a flat moving surface similar to the ordinary belt conveyors The reasons for using an apron conveyor at this point are two. First, the weight of the sand from shake-out falling on the ordinary belt conveyor would cause undue and dangerous strain, and secondly, the sand from shake-out is very hot when one considers that it has been next to and absorbing the heat from the molten metal in the casting. An ordinary rubber or fabric belt could not withstand these temperatures and give anything close to uninterrupted service. The metal of the apron conveyor solves the problem perfectly. This conveyor was also available for use

having been in the old steel foundry.

The apron conveyor was 28' long. In this distance, the sand being spread out upon the conveyor did cool to some extent. The apron conveyor emptied onto another 24" belt conveyor. On the discharge end of this belt was a magnetic pulley. Whereas, before the metal was separated from the sand by hand, now the magnetic pulley performed this function. The metal in the sand came from nails and other metal bars placed in the molds to hold the cores and strengthen the molds. Sometimes pieces of metal were placed in the flasks to cool parts of the castings more rapidly. The action of the pulley was this: sand, which was spread out on the belt ran over the pulley and the magnetic attraction of the pulley held the metal to the belt while the sand discharged off the end of the belt. As the belt turned back under for the return run, it ran past or out of, the magnetic attraction of the pulley and the metal dropped into a tramp iron box. Also the sand that was magnetized was taken out of the molding sand. Thus, when the sand left the magnetic pulley end of the belt, all the tramp metal and useless sand was taken out of it. The only thing that was left was to break it up finer and cool it more.

Previously, the breaking up of the sand was done by hand labor and it was cooled by working it over and letting the air get at it. In the new system, these two functions were performed but in this case, they were performed mechanically. The sand discharging off the magnetic pulley went into a royer. This mechanism has a cylinder with a spoke arrangement on it that effectively breaks up the sand more and then throws it out onto a new 24" belt conveyor. The throwing of the sand spreads it out allowing

the air to get at it, thus cooling it.

The 24" belt that the sand discharges onto carries it back to the sand mills where an elevator conveyor carries it up and dumps it into the sand mill. Thus, it may be seen that the necessary functions are performed on the sand without human hands touching it. The sand is broken up, cooled, the foreign matter taken out of it and it is milled and ready for use again.

On the diagram of the belts conveying the sand from the shake-out at the mills, it can be seen that the belts are slightly inclined.(1) The reasons for this are that they can discharge easily onto the next belt and also, that if the belts can be inclined, then less excavation has to be undertaken. The angle that a belt can be inclined at is not too great when one realizes that too great an incline would mean that the material on the belt would continually be sliding back and thus the belt would be ineffective.

On the diagram may be seen dust hoods at the belt transfer points. Dust is an important problem in foundry work. Too much dust in the air may affect the workers' health and is indispensable for good working conditions. Also, the dust has to be taken out of the sand. At the points where there is greatest dust, shake-out and belt transfer points, there are dust hoods. At these points, there is sufficient volume of air passed through to draw off all the dust. This air carrying the dust away passes through a filtering arrangement where the dust is collected and then it can be carried away in trucks to the dump. Most often, there are city ordinances which prohibit the release of the dust to the

1. Exhibit 5.

atmosphere and for this reason, when handling any material which is liable to create dust, some provision must be made for the control of it. Some dusts are explosive and care should be taken in handling them.

Again, looking at the sand transfer belts, it can be seen that there are three chutes where the sand may go after it leaves the magnetic pulley end of the middle belt. One chute is for the tramp iron as was explained before. It is back far enough so that the sand does not carry down the chute. The other two chutes are for the sand. One chute leads to the royer which breaks up and cools the sand. The other chute is a standby in case the royer breaks down. The tramp iron box has to be emptied about twice a day. It can be easily done by one of the overhead hoists which serves the turntable. All that has to be done is to pick up the box and place a new one under the chute. The same system is used in emptying the scrap that happens to get by to the royer. (Royer scrap chute on the diagram.)

There was only one other place where the sand had to be taken care of and that was the spill sand on the turntable. After the flasks are filled, the top is scraped off and this sand has to be taken care of. The sand used in the system came from a distance of over 200 miles and was rather expensive so that any wastage of the sand was to be avoided. The means of taking care of the spill sand was this. The sand was struck off at a certain point on the turntable. This sand fell through a grate and was guided by a funneling arrangement which guided the sand onto a conveyor belt beneath the table. Since this sand might have collected some dirt on the table, the sand was sent back to the mill. The belt emptied onto the magnetic pulley belt and went through the same reclaim

process as that from the shake-out. In fact, it was mixed with the sand from the shake-out.

Thus, it can be seen that the required amount of sand was supplied by the system and waste was eliminated,all without having to resort to human labor.

Next, we will consider the handling of the flasks. A pallet conveyor was the means decided upon for conveying the flasks. Since the flasks would have to be placed on after coming off the turntable and since they would have to be lifted out for shake-out, it was advisable to have a conveyor which would not require a great deal of care in placing the molds on. A pallet conveyor with a flat surface seemed like the best thing to do the job. The conveyor is a series of metal plates supported on wheels which run on a track laid in the floor. The plates overlap each other thus giving a smooth flat surface. The conveyor has a capacity of 82 trays which is more than is needed, but will be useful if a speed-up is required. The conveyor has a chain drive underneath. The wheels of the conveyor ride on T tracks which eliminates the possibility of stray sand clogging up the rails and slowing down the conveyor. The speed at which the conveyor can be driven is variable from three to six feet per minute. This variation is necessary depending upon how long a cooling period is desired. The plates on the pallet conveyor are 34" x 51" which makes fitting the flasks (29" x 29") an easy task.

The route of the flasks is as follows.[1] The flasks, when filled, are taken off the turntable by a traveling overhead crane and placed on the conveyor. The distance from the table to the conveyor is

1. Exhibit 2.

a matter of a few feet so the operation takes only a short while. One may ask the question, "Couldn't a means be devised whereby this handling could be eliminated?" As to the possibility of filling the flasks right on the pallet conveyor, this would be impractical because it would mean stopping the conveyor several times. When the cores are set, the conveyor would have to be stopped and also since both cope and drag are filled separately and then placed together, it would mean that more space than practical would have to be allowed on the conveyor to do the job adequately. There would be one mold in the space where two are placed with the method chosen. Also, one may say that another solution to the problem would be to pick the flasks off the table with a hoist and carry them around their path through the plant on a monorail. This would not work for many reasons. First, the building could not stand these overhead stresses. Also, it would make pouring difficult as it would be hard to keep the flask level. After consideration of all these possibilities, the pallet conveyor was decided upon.

Getting back to the route of the flask, the next step after being placed on the conveyor was pouring. The conveyor carried the flasks along about 30-40 feet to the pouring area. The pouring area extended along 40' of the pallet conveyor. It is as close to the turntable as possible, enabling as much of the conveyor for cooling as possible. The closer to the turntable, then the less length of conveyor required.

Pouring is done with one-ton ladles supported by an overhead monorail. The reason for only one-ton capacity ladles is again due to the fact that the building structure could not withstand greater weight.

The ladles are filled at the cupola which is located in the north end of the foundry. The cupola was kept in the same place as before, as it would be too much trouble and expense to move it as compared with the savings it would mean if it were closer to the pouring area. The ladles were carried from the cupola by a hoist traveling on an overhead monorail. The ladles were carried in this manner to the pouring area about 150' away. At the pouring area, the monorail split into a loop. A switch enabled the full ladles to be switched onto the pallet side of the loop. After pouring, the ladles completed traveling the remainder of the loop back to the switch. Here they were switched back onto the single run monorail and were taken back to the cupola. There was enough storage space provided, the loop was made big enough, so that full ladles could be brought up and put on the pallet side of the loop. While these were being poured, the empty ones could be brought back over the same monorail without interrupting pouring.

The full ladles were synchronized with the pallet conveyor in order to facilitate pouring. This eliminated the necessity of stopping the pallet conveyor for pouring. The monorail hoist engaged with a dog carrier which carried the ladle along at the same speed as the conveyor. The ladle could take care of seven or eight flasks. Pouring was completed with a minimum of human effort. The pourer had full ladles supplied to him, allowing him to pour all day.

The flasks, after being poured, traveled down the foundry for another 125' where the conveyor made a loop and returned to the shake-out. The length of the pallet conveyor and the speed were so arranged that the flasks spent fifty minutes cooling before coming to shake-out.

Another thing that had to be taken care of in the cooling run was that of gases. When a flask is poured, the hot gases coming out of the flask have to be taken care of or it would make the place unbearable. The means of taking care of this was a hood arrangement. The hood, with sufficient draft, collected and carried away all the gases.

So far, the sand handling, pouring, shake-out and flask conveyor have been described, but we still have to consider in more detail, the actual handling and filling of the flasks on the turntable. Also, we must consider the core handling. After shake-out, the empty flasks, cope and drag are placed back on the pallet conveyor and carried back to the turntable. Here the cope is lifted off and placed over the pattern on the turntable. The drag is also liften off by an overhead hoist and placed on the next spot on the turntable. As the table moves around, these both go past the sand slinger and are filled with sand. Since cope and drag are the same size and interchangeable, it doesn't matter which one is set over which pattern. After the sand slinger, the drag is turned over and the pattern taken out. Then the cores are set. These could be set either by hand or with the assistance of an overhead crane or hoist. After the core is set and anything re - quired done to the face of the mold, the cope is placed over the drag and the flask is ready for the pallet conveyor. The flask is lifted onto the conveyor as explained before and the rest of the operation takes place.

The cores are not made at the same foundry. Since there were several core-blowing machines in another steel foundry which were not being used to capacity, it was decided to let these machines do the core

making. The core sand was milled there and they were baked there also. The cores when completed are brought over to the new foundry twice a day and stored in the space between the turntable and the south end of the wall. The matter of cores was one of the things that was going to be let go until the foundry was in actual operation and the flaws were worked out. Of course, making the cores in another foundry and carrying them over resulted in a lot of handling. There were three possibilities for the core making in the future. One was to make them the same as before in the steel foundry. Another was to make them in part of the iron foundry, perhaps the space used for storage of the cores, although this was rather small. Some of the space would still have to be allowed for temporary storage. The third and most likely was to set up a separate core room. This would be either to build an additional core room near the turntable or to put up a Quonset hut. The core-blowing machine could be placed in it and a small mill for core sand set up.

Another problem that was left until the plan went into actual operation was what to do with the castings after shakeout. The space between the pallet conveyor and the west wall was rather narrow but either electric trucks or a conveyor machanism could be installed later to take care of them. For the present truckers could handle the volume. Another solution would be to cut a hole in the wall and take them over to a clearing room in a building which was right behind it. Whatever the solution, it was delayed until it could be determined just what volume of production could be attained with the new system and how good the castings would be. That is, how much work would

have to be done on them after shakeout.

With all systems there must be some provision in case of breakdowns. In this case, the system was one of preventive maintenance. A system similar to this, only not as mechanized, was in operation in one of the other foundries of the company. Here they had found the points to watch for breakdowns. Spare belts were to be kept on hand at all times. Belts could be changed on the off shifts. It was found that if a belt was going to let go it could be detected in advance. If one did break down in operatinn, it could usually be repaired good enough to last the rest of the day. The belts very seldom broke down. Moving parts and points of wear on the machinery could be replaced regularly. As an example, a steel plate on the sand slinger would wear out in abouy 36 hours of operation from the sand wearing on it. This plate was replaced regularly before a breakdown could take place. It took a matter of minutes.

The advantages of the new set-up are many. It can be seen that practically all of the hand labor hasbeen eliminated. No longer are the men mixing their own sand which means not only the reduction of hand labor but that the sand is more uniform in quality since it is all mixed together.

No longer do the men have to pick up their own filled flasks (most of them were smaller but weighed over fifty pounds) and carry them to the place of pouring. Pouring does not take place in many locations thus cutting down not only the extra handling and handling equipment required but also cutting down the number of pourers required.

This means that a man pouring doesn't spend half of his day waiting to pour.

Shakeout no longer takes place in several different locations. The men do not have to use up so much hand labor breaking out the flasks. The loss in sand is less. Truckers do not travel several different routes to collect the finished castings. Now they collect all the castings at the same point.

The space of the plant is utilized to a much greater extent. For the same space used and with the same cupola, the output of the foundry was increased from 20 tons to 50 tons for an eight hour day. In fact the previous 20 ton production was attained in more than eight hours because after pouring in the mid-afternoon a new shift of workers came on and did the shaking out and the cleaning out. This increase is mainly due to better handling which enables continuous pouring. This is an increase in production of 150 per cent.

The labor force required to meet this production is about 40 per cent of the previous force. Before there were twelve molders' groups of two each, two men at the cupola, two men delivering cores and taking away finished castings, and a second shift clean up crew of eight more men. The total number of men employed was thirty-six. With the new layout and equipment the labor force consists of two men at the cupola, two pourers, one man at the sand slinger, two men on the turntable, two men working the hoists on the shakeout monorail, two men at the shakeout table, two men delivering cores and taking away finished castings, and one man at

the hoist lifting the finished flasks off the turntable and onto the pallet conveyor. The total men now required is fourteen. This is slightly less than 39 per cent of the previous labor force. This reduction in the labor force also reduces the labor payroll about 60 per cent.

Thus production is up 150 per cent and labor costs are down 60 per cent. These savings have to be balanced against the cost of purchasing and maintaining the new equipment. Though exact figures were not made available on these costs, the resulting savings were reliably stated to be much greated than the cost of the new layout.

The space required for storage of the finished flasks and sand has been greatly reduced. No longer are there rows of finished flasks waiting to be poured. Now the flasks are poured in a matter of minutes after they are completed. Fewer flasks are required which reduces the amount of maintenance. The amount of machining that has to be done every so often to make sure the cope and drag set properly on each other is cut down. Now less than one hundred flasks have to be maintained.

Many other advantages are had. The cupola is now allowed to operate continuously from the start of shift to the end. This means greater utilization of the equipment which helps to cut down overhead costs.

There are other advantages of the new system that are hard to evaluate in terms of money but they are certainly important. The working conditions have been greatly improved by the reduction of dust and gases in the air. Also there is less sand and dirt around the floor.

The quality of the castings has become more uniform due to the fact that the sand is more uniform and the whole process can be controlled easier and better. Due to the reduced number of molders required, the expert ones can be used. All these factors add up to a more uniform quality of the product.

CHAPTER 6

CONCLUSION

In the preceding chapter a picture of how the principles outlined in chapter three may be applied to an actual case has been attempted. Similar situations could be taken and a solution obtained, but this would become involved and lead to repetition. It is hoped that by this one example the reader may obtain an idea of how to apply the principles to other situations.

In applying the principles to a particular situation variout conclusions may be drawn about the general ideas to follow for good handling. The principles when applied to one type of industry may lead to one set of conclusions about the best layouts and equipment for good handling. When the same principles are applied to another industry there may be a different set of conclusions. For example, we can take the foundry just described, Here we can see that by applying the principles to a foundry we come to the conclusions that;

1. No real economies can be obtained in handling unless the various operations are centralized.

a) Centralize pouring.

b) Centralize shakeout.

c) Dentralize filling of the flasks.

2. The centralization as described in (1) cannot take place unless some degree of standardization takes place.

a) Standardization of the varioud prdducts.

b) Standardization of the sizes, shapes, etc. of the materials to be handled.

3. In order to get increased production the handling system should allow continuous pouring.

a) Pour the flasks as soon as they are made up.

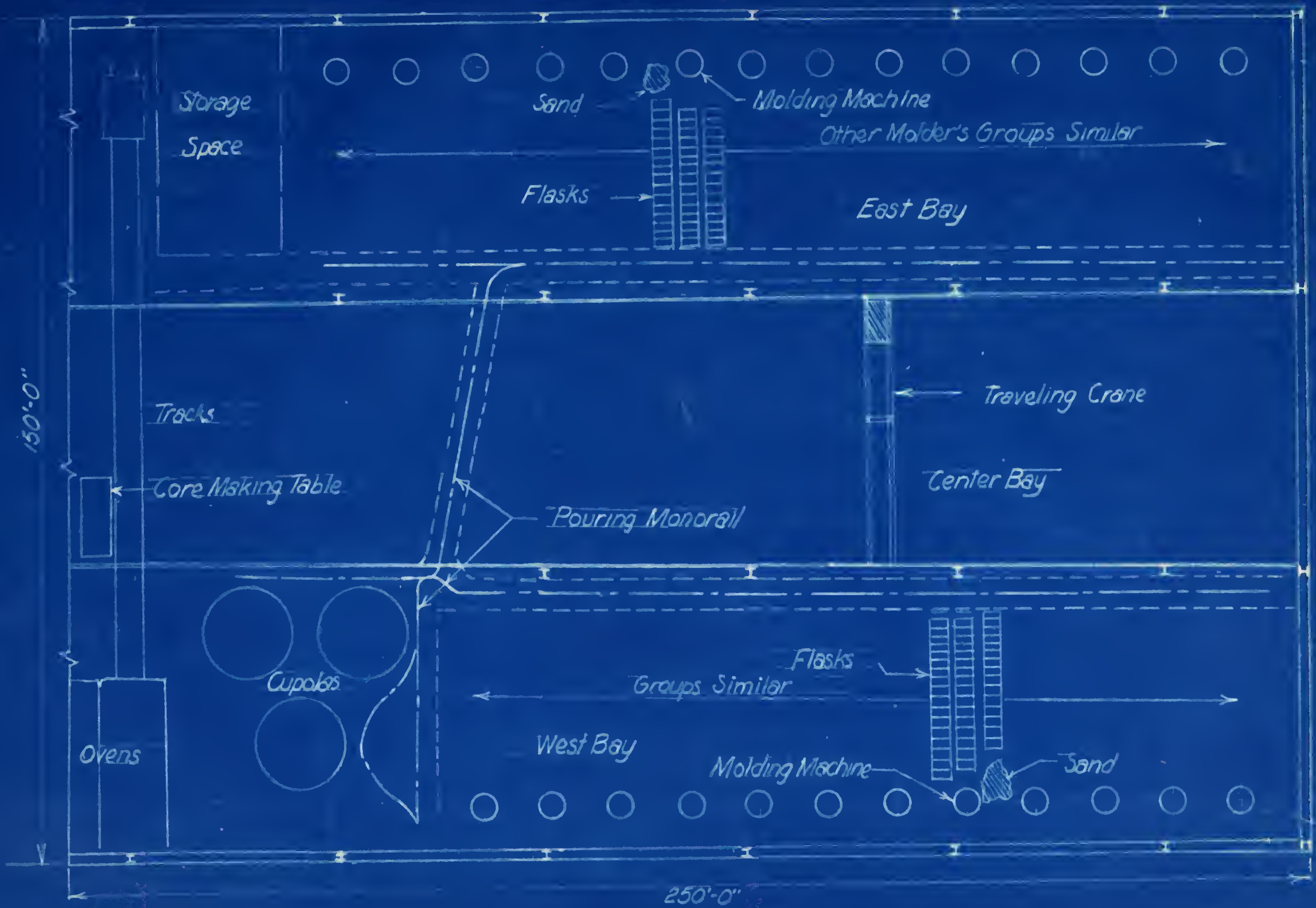
4. The greatest economies can be obtained when the sand is handled and milled by mechanical means.

a) Due to the large amounts handled this feature is imperative.

In the case of a machine shop, warehouse, or chemical plant the conclusions may differ but the underlying reasons for each conclusion may be found in the principles outlined in chapter three.

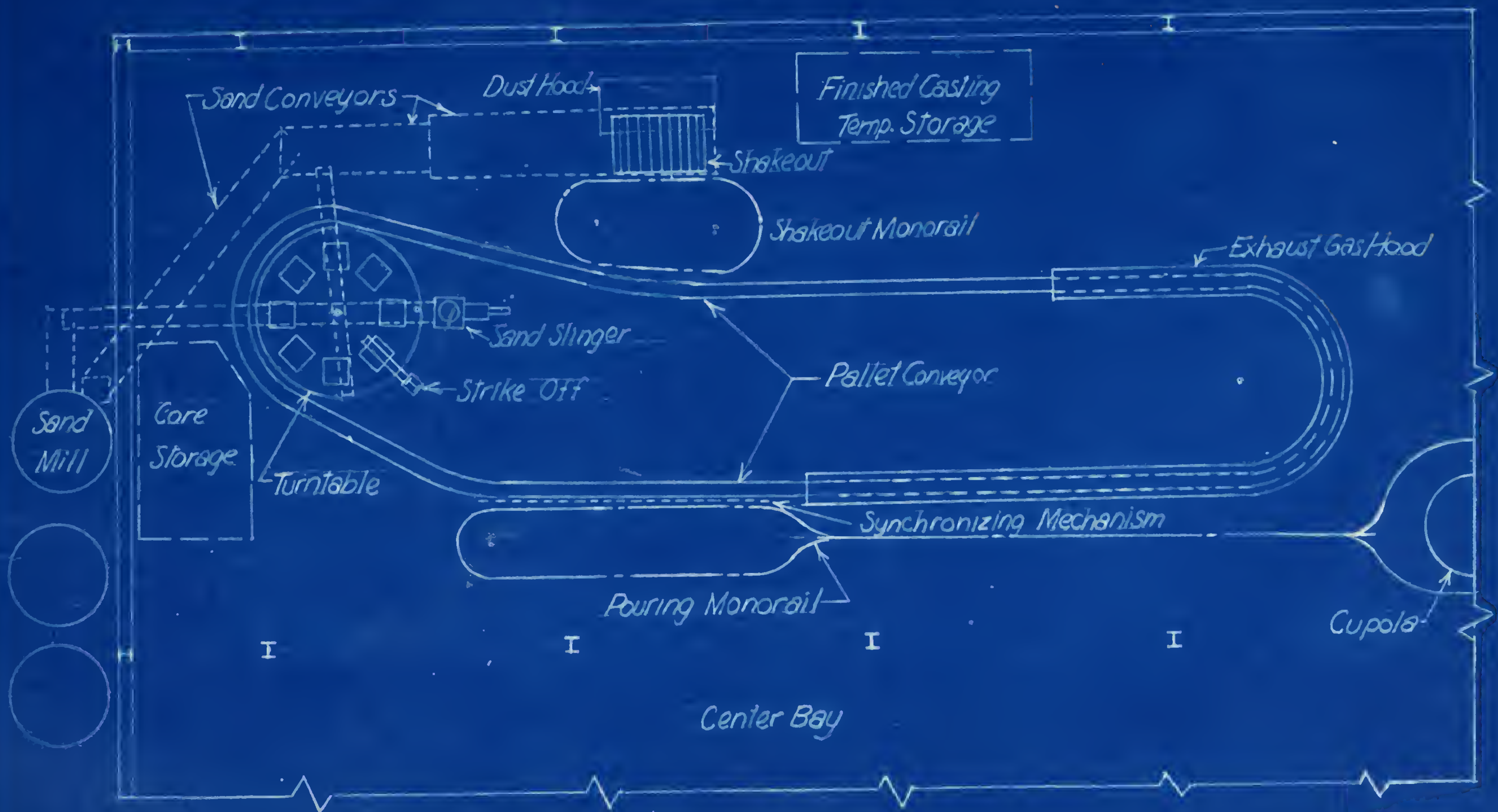
For the conclusions drawn about the foundry the main principles involved are standardization, full utilization of the equipment, reduction of handling whenever and wherever possible. In other cases some of the other principles may be dominant factors but in every case there will be one underlying thought and that will be the reduction of handling everywhere possible.

In closing too much emphasis cannot be placed upon the importance of handling in modern industry. Advances are being made in the field and it should be the job of anyone in the field to keep in touch with these advances. No matter how well one thinks he has his handling problem solved, he should be constantly looking for ways of improving it. The list of equipment in Chapter two, though rather complete as to the types of equipment available, may in the course of a few years become outmoded by new variations and improvements in the existing equipment. The handling man should keep in touch with these new advancements and new applications. He should be continaully be trying to cut down the handling of a minimum.



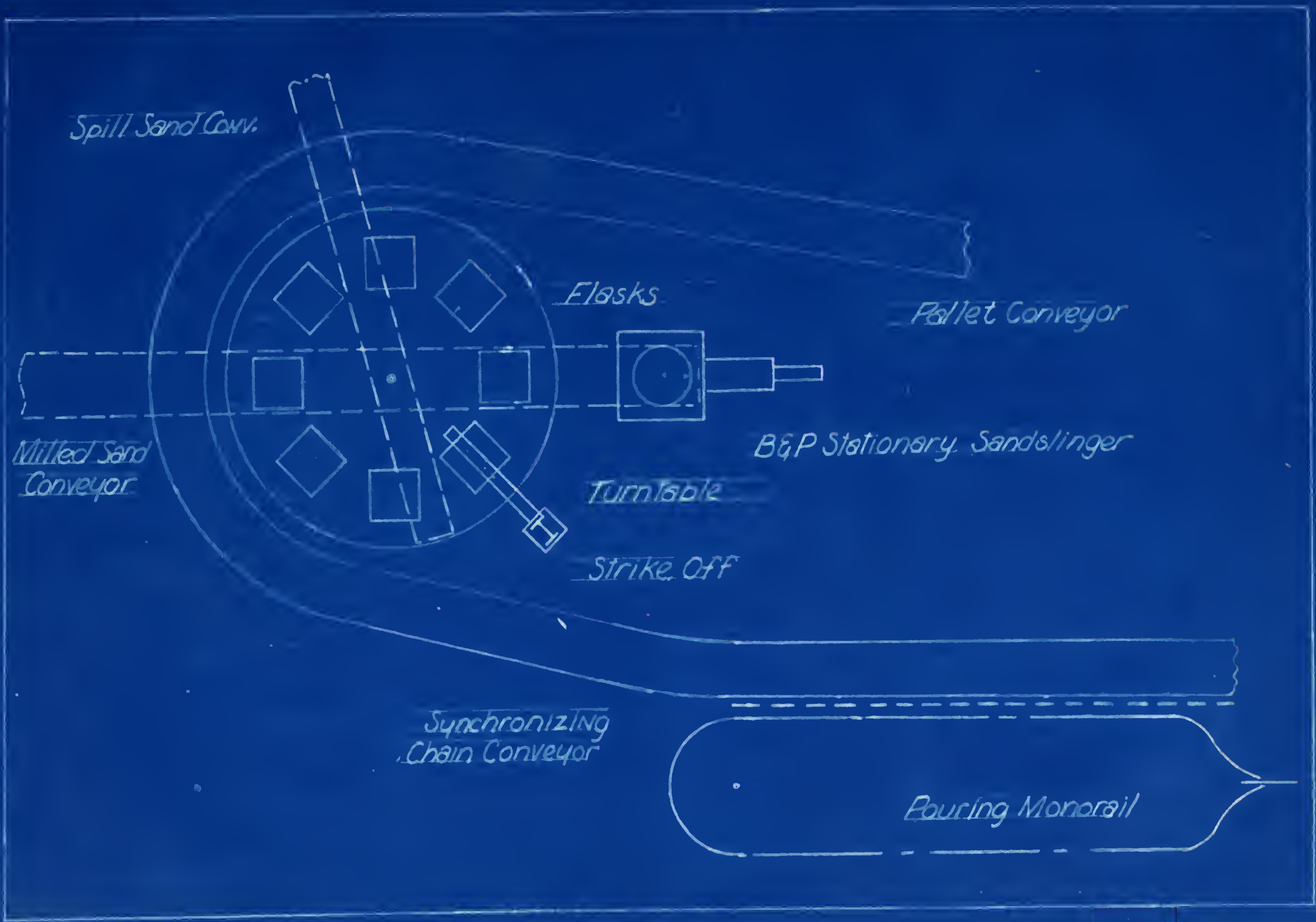
Layout of Old Foundry

Exhibit I



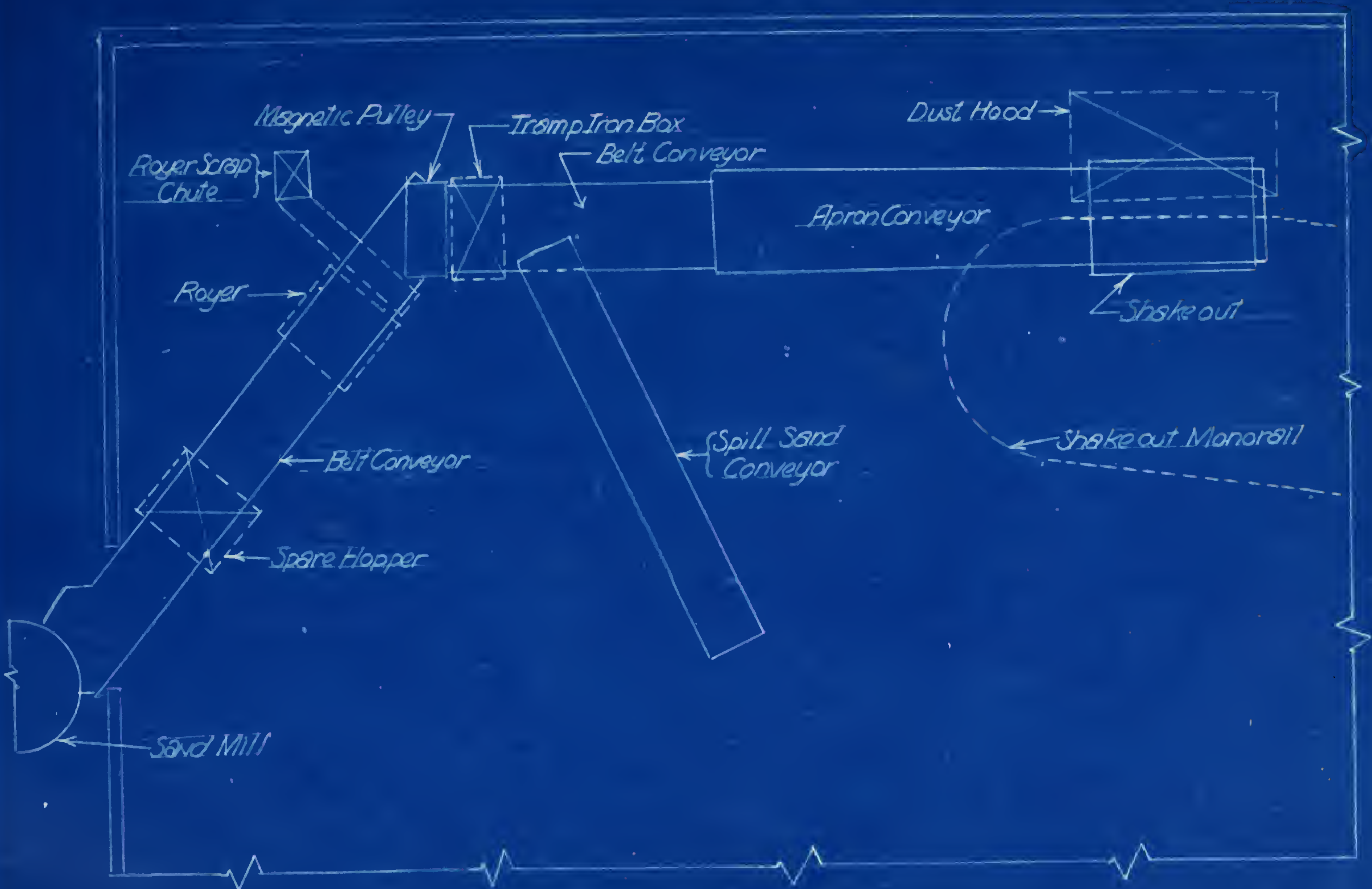
New Layout of West Bay

Exhibit 2



Turntable & Pouring Area

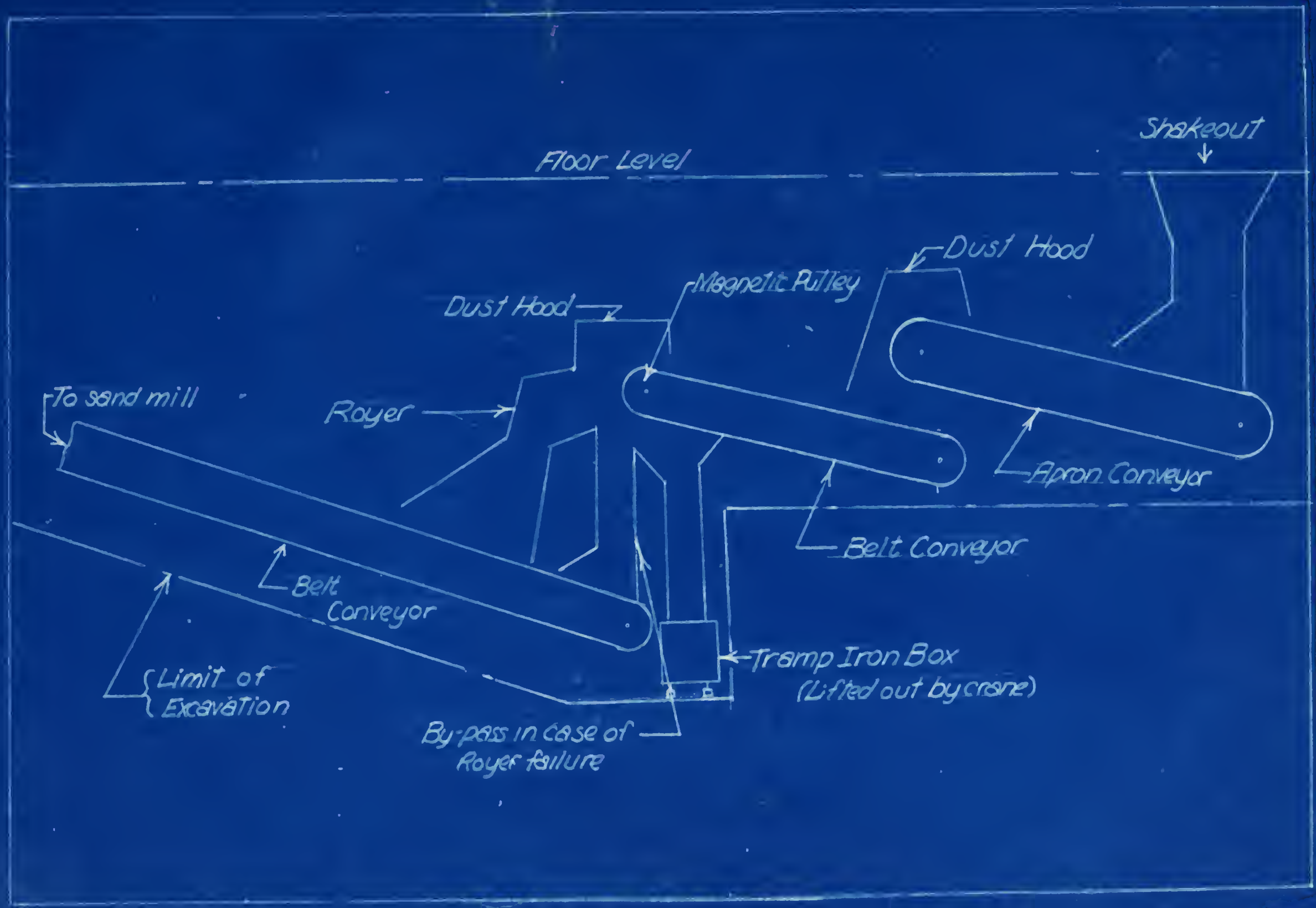
Ehibit 3



Reclaimed Sand Handing Conveyors

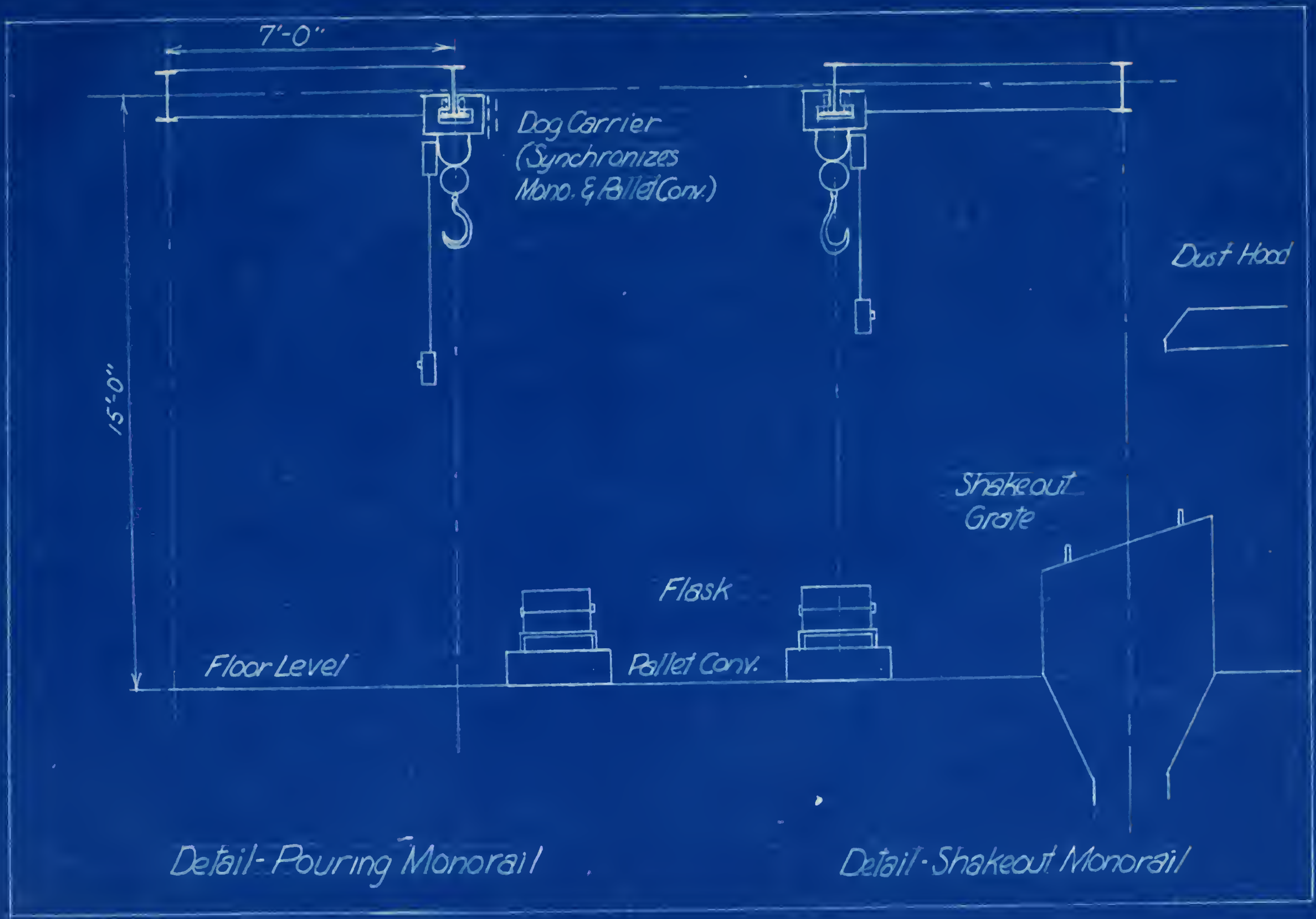
Note: All conveyors under floor surface

Exhibit 4



Cross-Section of Reclaimed Sand Conveyors

Exhibit 5



Details - Hoists & Monorails

Exhibit 6

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